Reducing Uncertainty of Near-shore wind resource Estimates (RUNE) using wind lidars and mesoscale models

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Reducing **U**ncertainty of **N**ear-shore wind resource **E**stimates (RUNE) using wind lidars and mesoscale models

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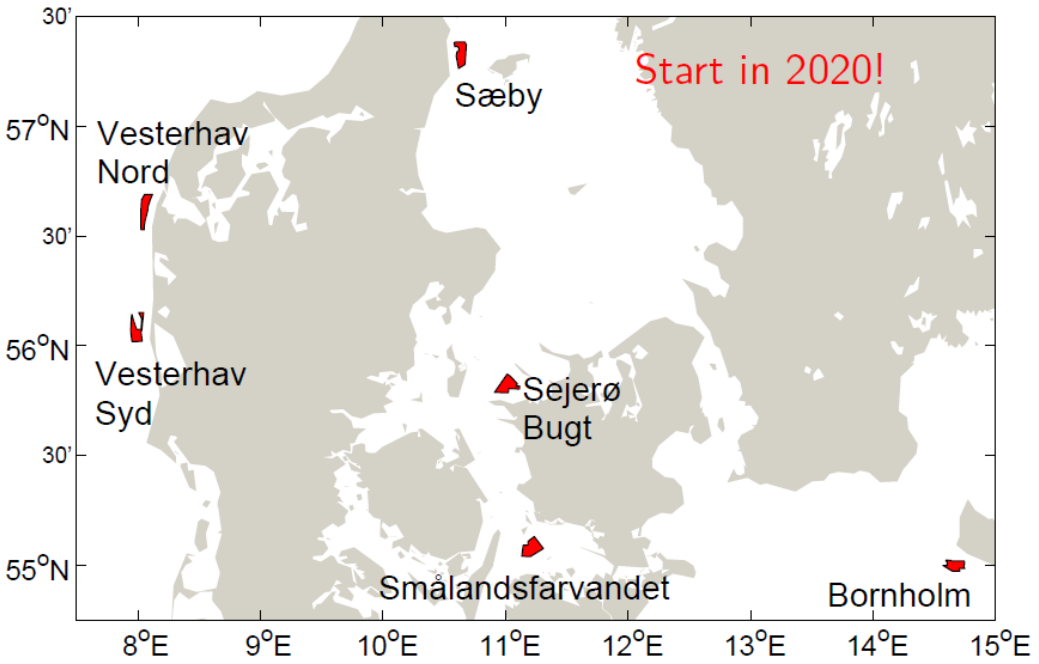
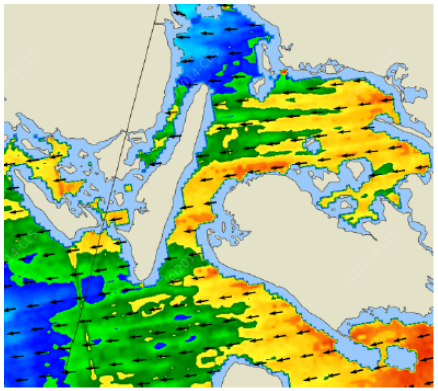
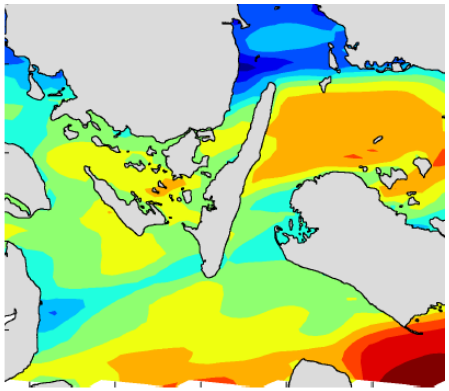
Motivation

- Many offshore windfarms planned in near-coastal waters due to high winds and good grid connectivity
- Big uncertainty in coastal wind climate due to change in roughness and stability conditions
- Wind lidars and mesoscale models became reliable tools to study wind development
- Are mesoscale able to capture flow with sufficient accuracy in coastal areas?



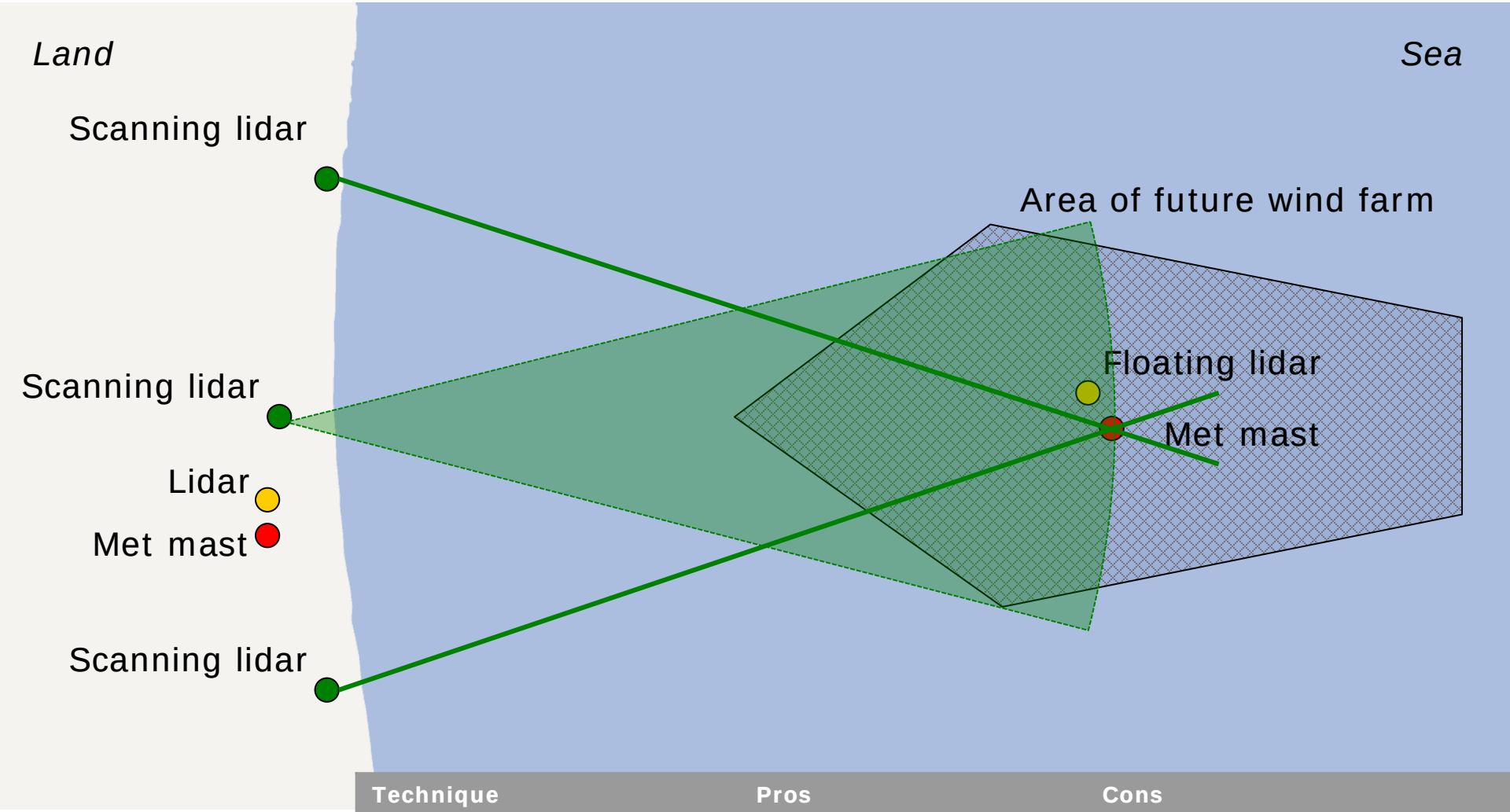


SAR 10-m winds



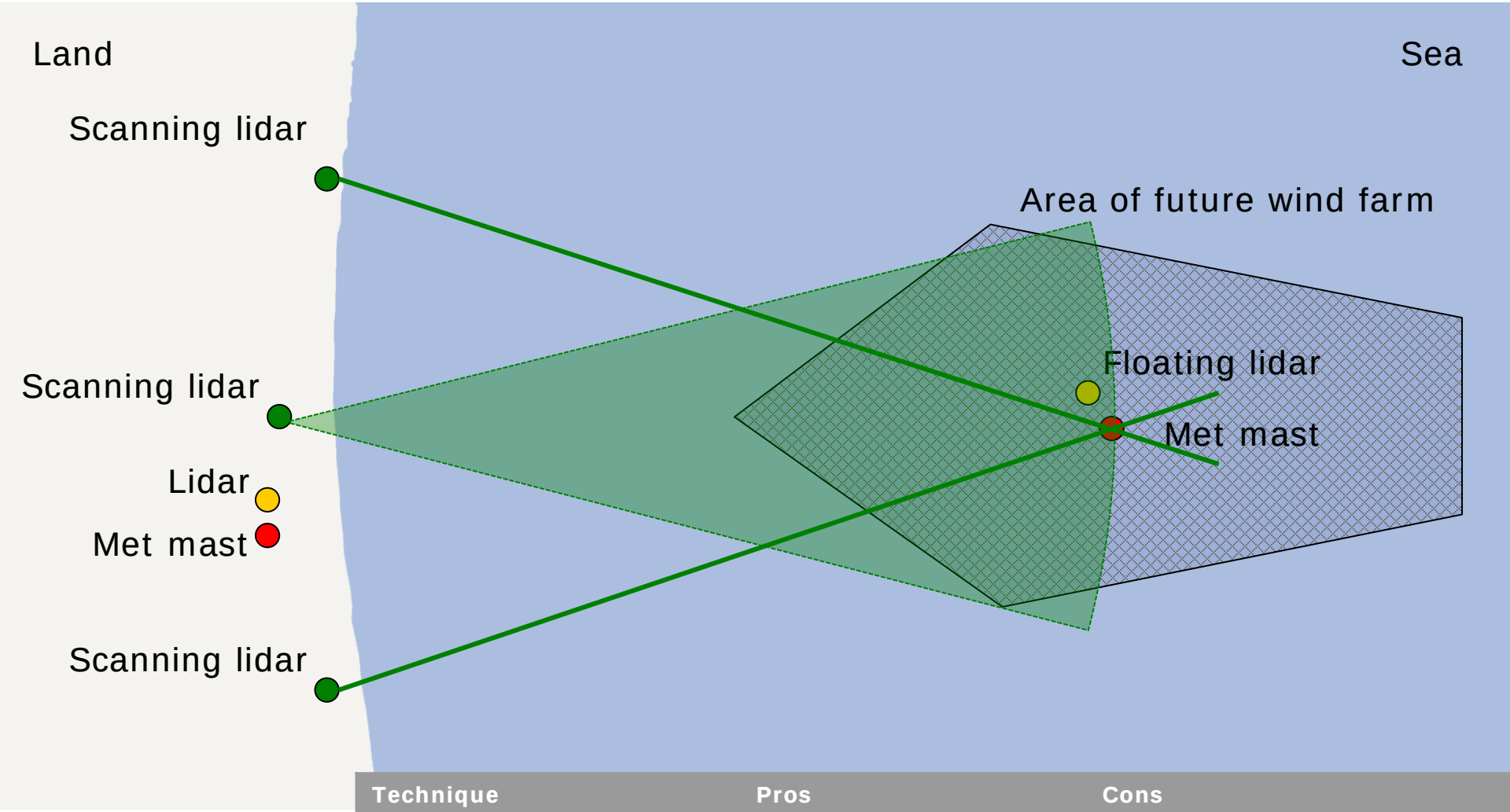
WRF 10-m winds

Options for measurements in coastal areas



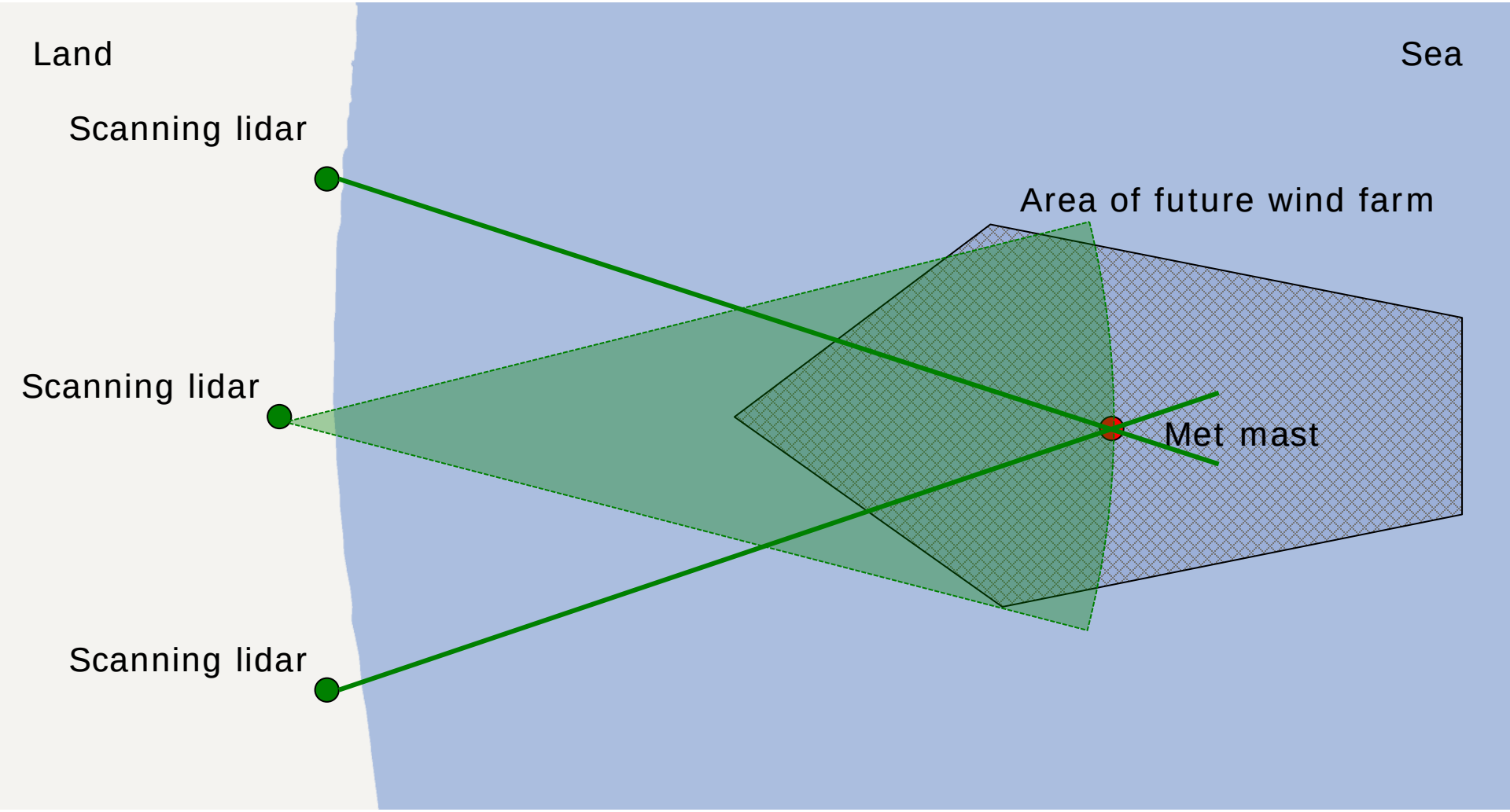
Technique	Pros	Cons
Mesoscale models	Cheap	Uncertainty of prediction up to 10%
Mesoscale models + local measurements	Uncertainty reduced to 3%	

Which measurement solution is most cost-effective (cost vs. accuracy)?

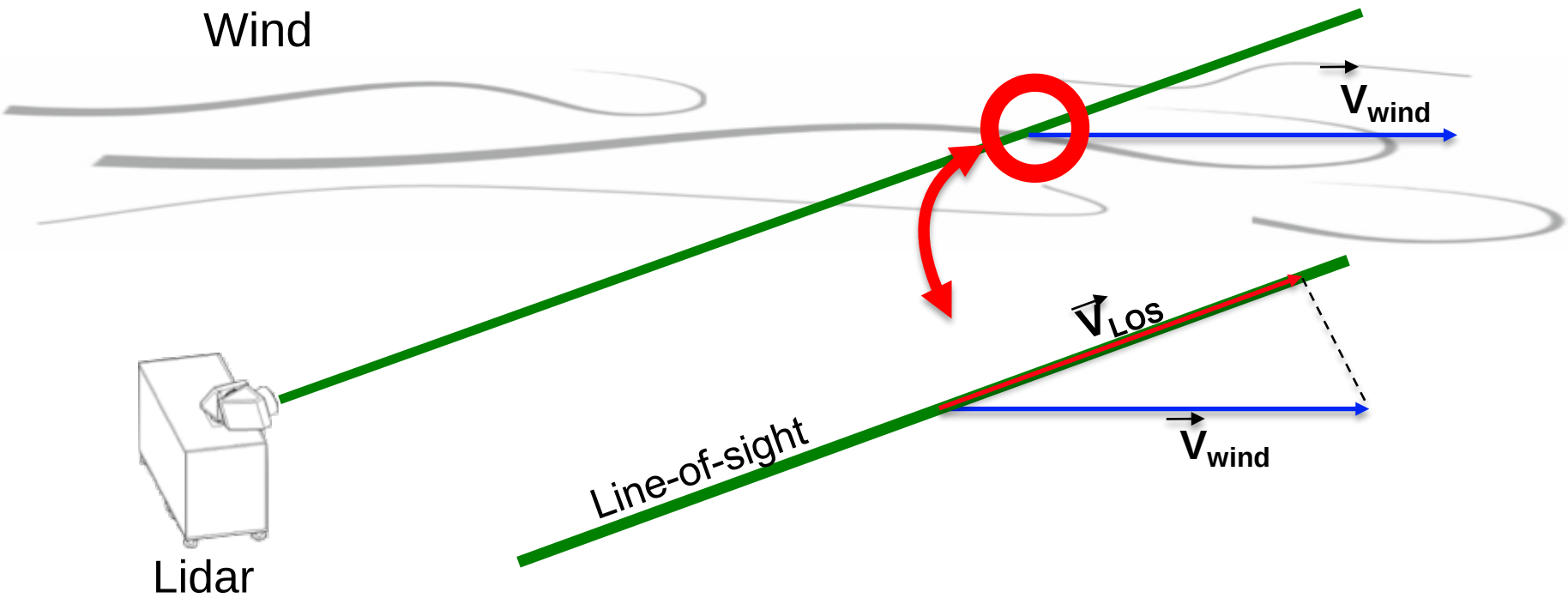


Technique	Pros	Cons
Mesoscale models	Cheap	Uncertainty of prediction up to 10%
Mesoscale models + local measurements	Uncertainty reduced to 3%	**$$$?**

First attempt to answer the question: One or two lidars?

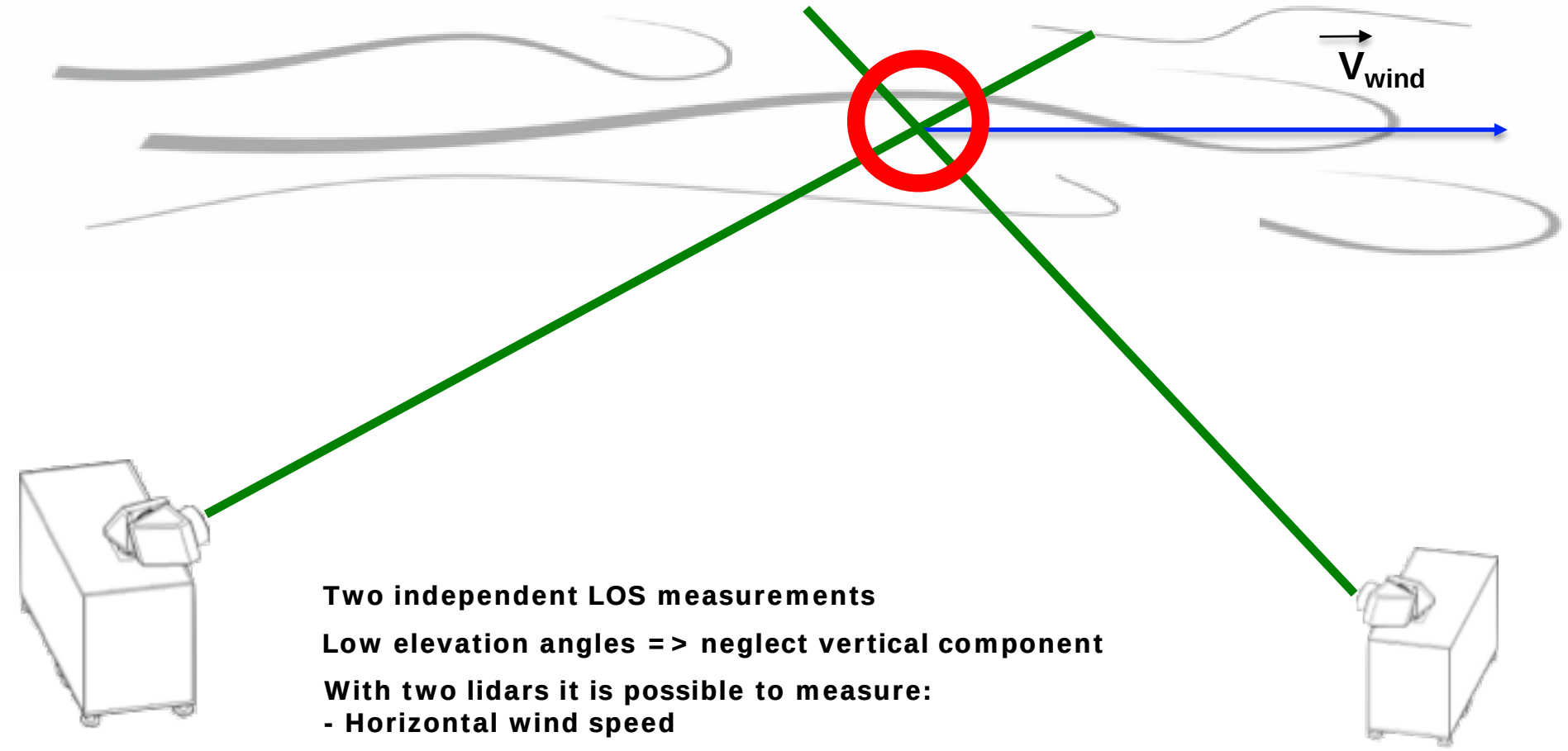


Lidar measurement background



A lidar can only measure a portion of the wind vector!!!

Dual-Doppler

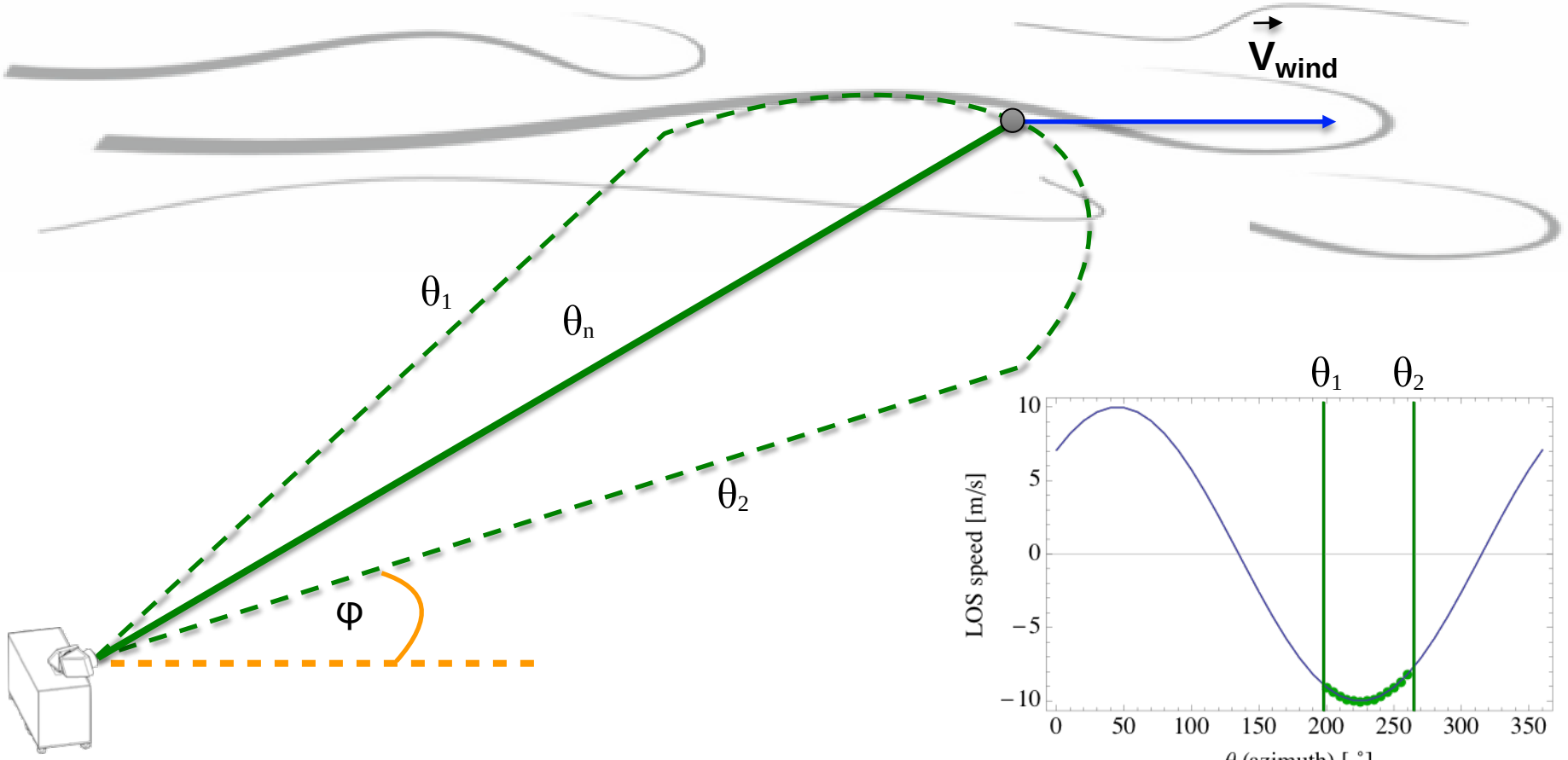


Two independent LOS measurements

Low elevation angles => neglect vertical component

With two lidars it is possible to measure:
- Horizontal wind speed
- Wind direction

Sector scan



Flow horizontally homogenous

Vertical component low } **Neglect vertical component**

Low elevation angle

Sector scan => estimate horizontal wind speed and wind direction

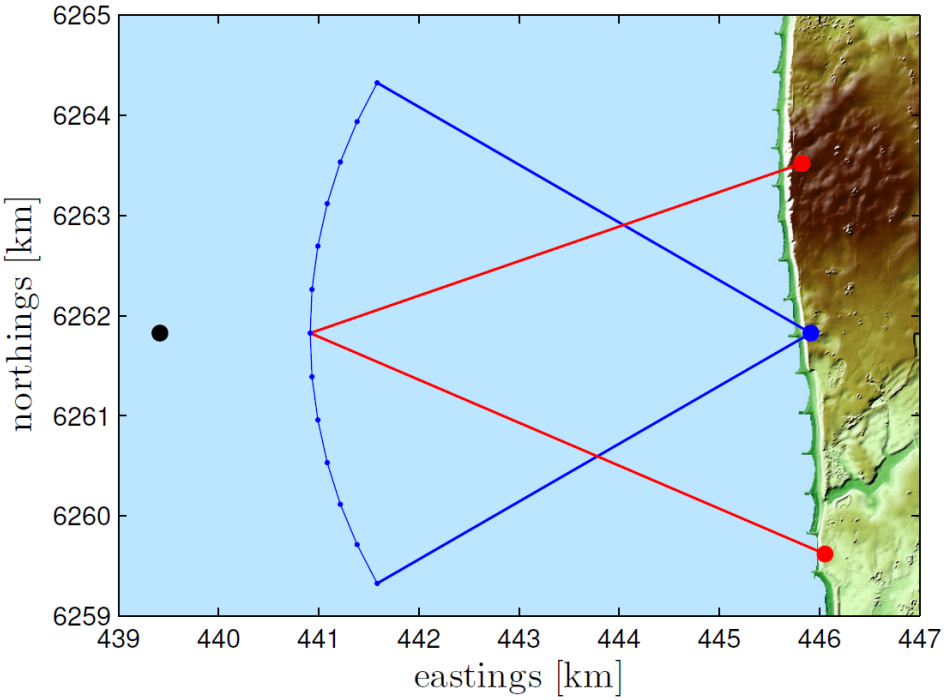
$$< V_{LOS} >= a\cos(\theta - b)$$

$$V_{horizontal} = a$$

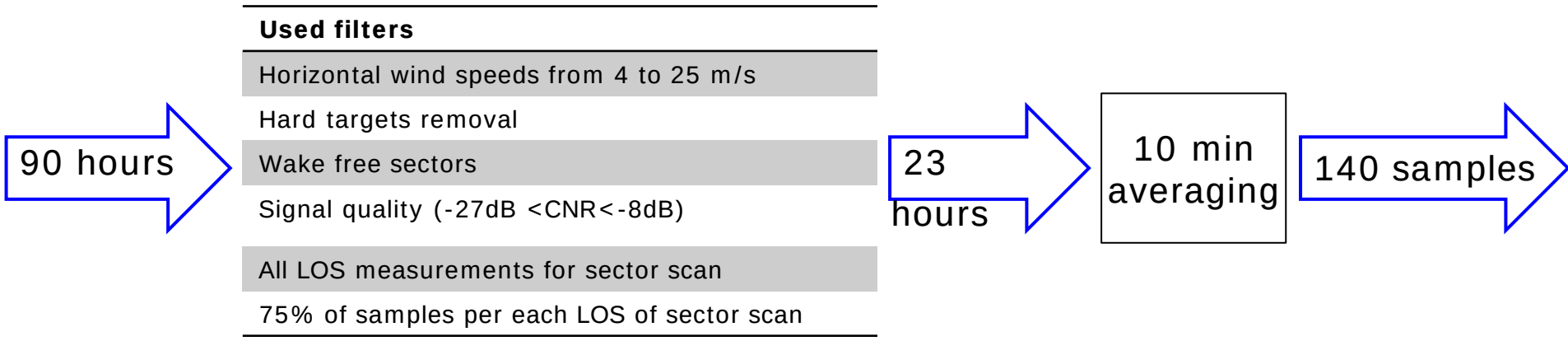
$$Wind\_direction = b$$

Measurement set-up RUNE, sector scan vs. Dual-Doppler

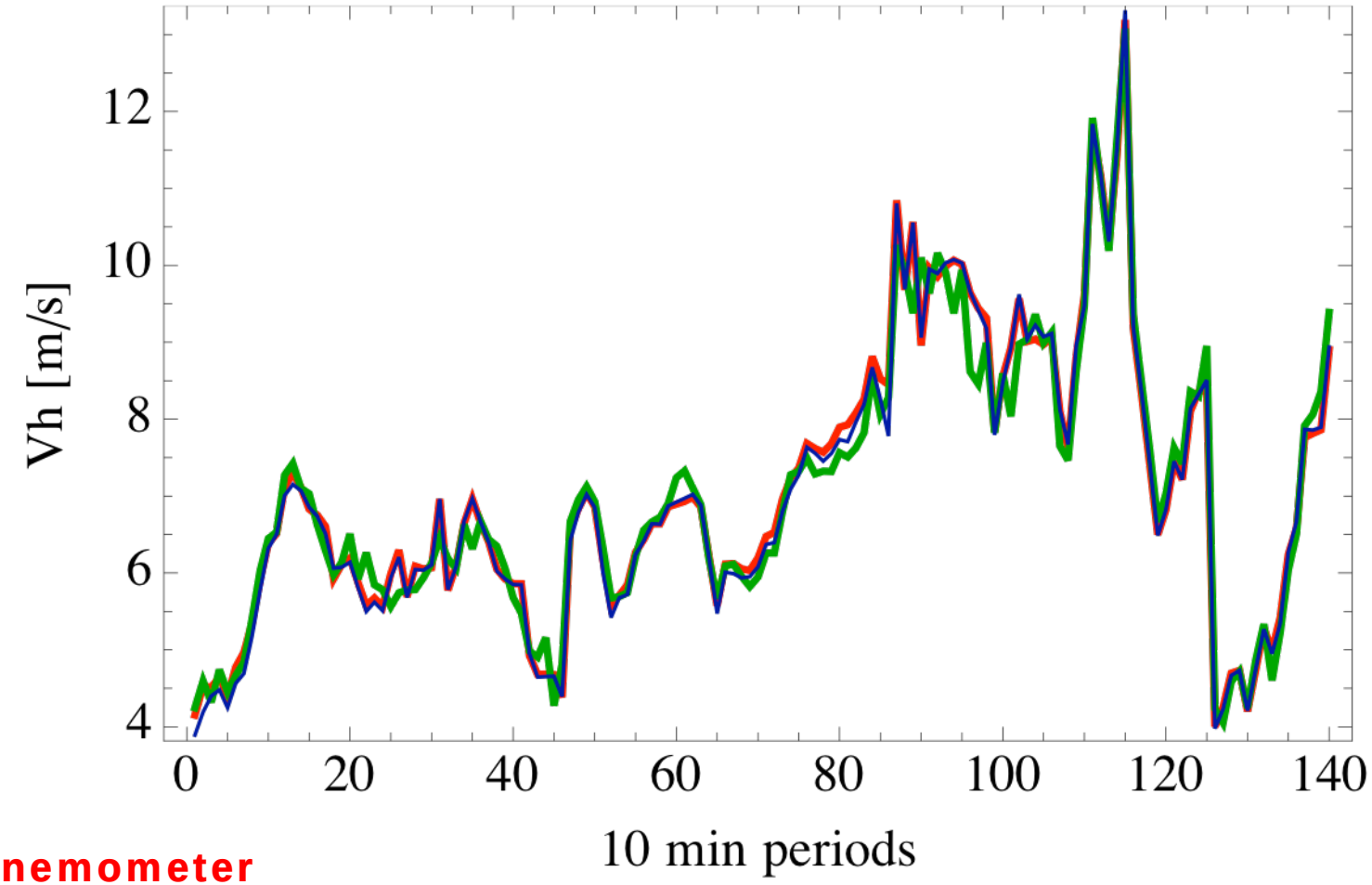
- Measurement campaign: locations chosen
- Period: October-December 2015
- Sea surface temperatures / wave parameters available (important to evaluate mesoscale model)
- Offshore floating lidar
- Onshore vertical shooting long-range lidar (wind profile 0-2000 m)
- Dual doppler setup scanning pattern from approximately 5 km up to shoreline
- Scanning lidar over same distance (range gates 50 m)



Pre-RUNE experiment, April-May 2014



Horizontal wind speed



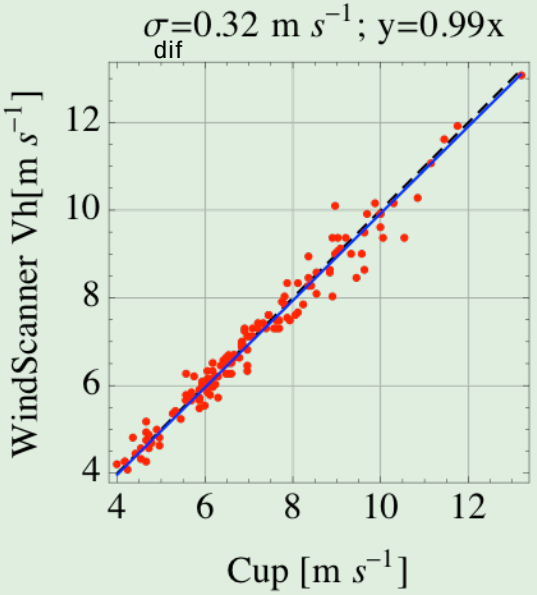
Cup anemometer

Two lidars (Dual-Doppler)

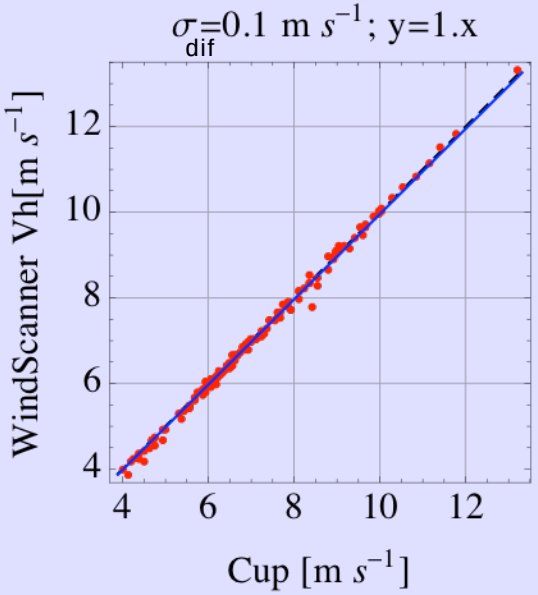
One lidar (Sector Scan 60°)

Horizontal wind speed

One lidar (Sector Scan 60°)

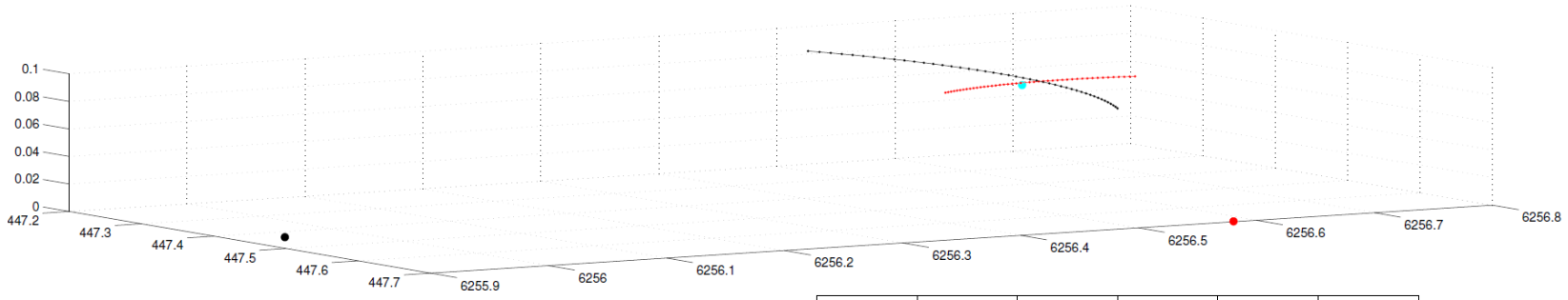


Two lidars (Dual-Doppler)

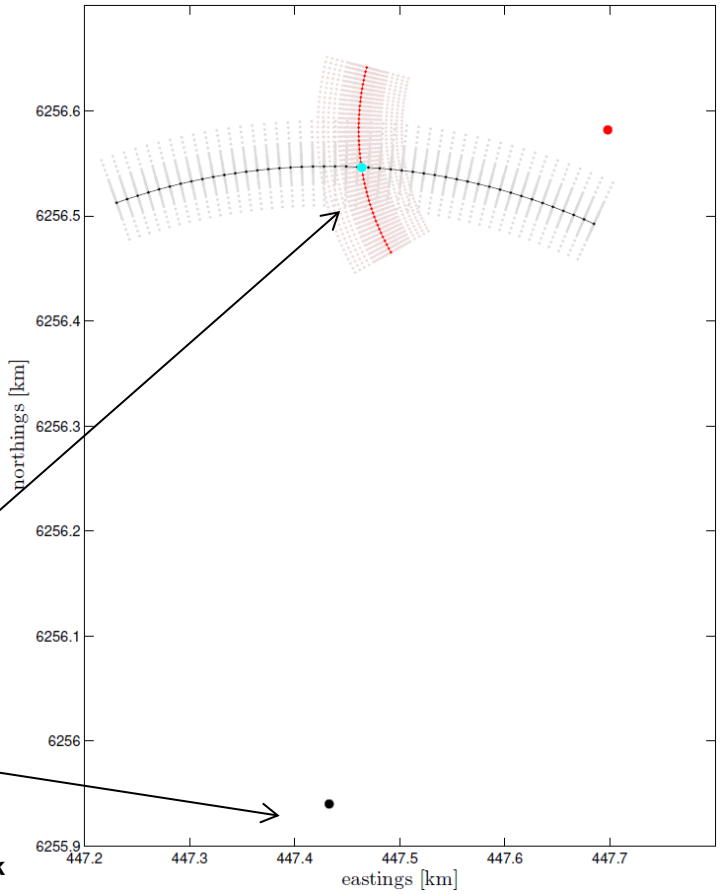


	Cup	One lidar	Two lidars
Number of samples	140	140	140
Mean wind speed [m/s]	7.07	7.04	7.04
R^2	/	0.98	0.99
Difference [m/s]	/	0.03	0.03
Difference [%]	/	<1	<1
Standard deviation of the difference [m/s]	/	0.32	0.10

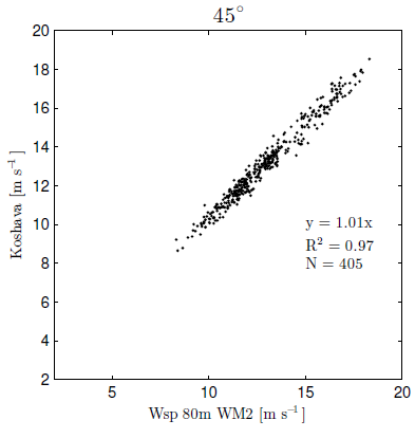
What is the best azimuthal angle for scanning?

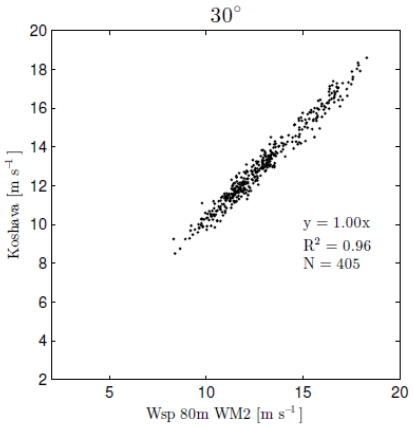


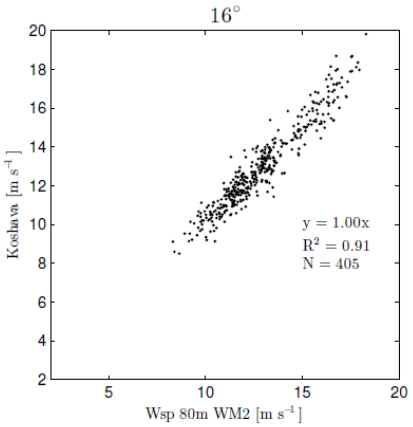
- Compromise between having a very large angle giving a large part of the sinusoidal and therefore certain wind speed, but homogeneity is questionable
- Small angle gives less certain wind speed but confined to a smaller spatial area

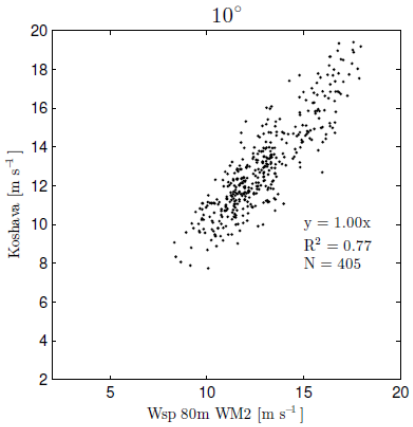


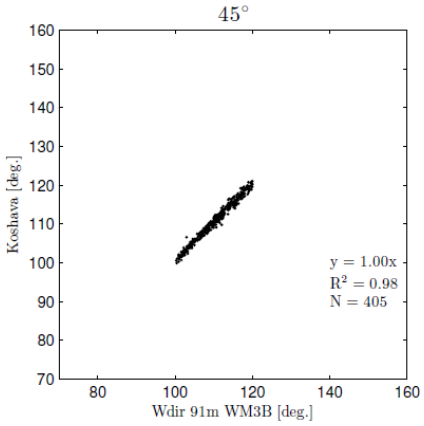
Results of comparison cup anemometer@80 m vs. scanning lidar at same point for different scanning angles

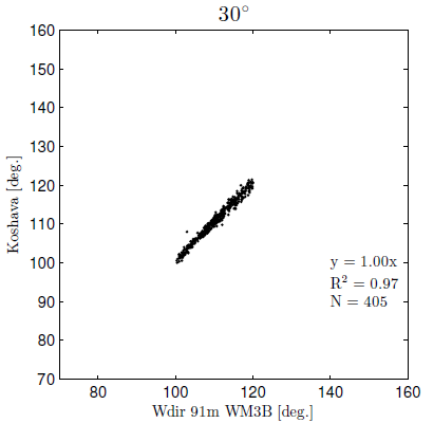


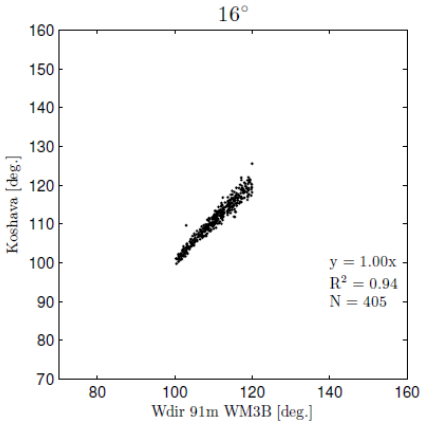


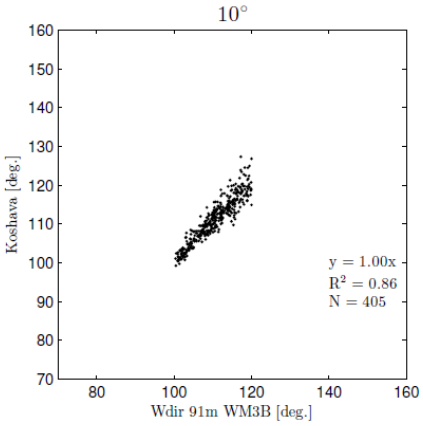






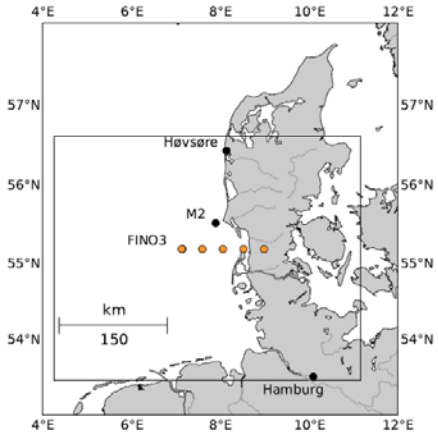


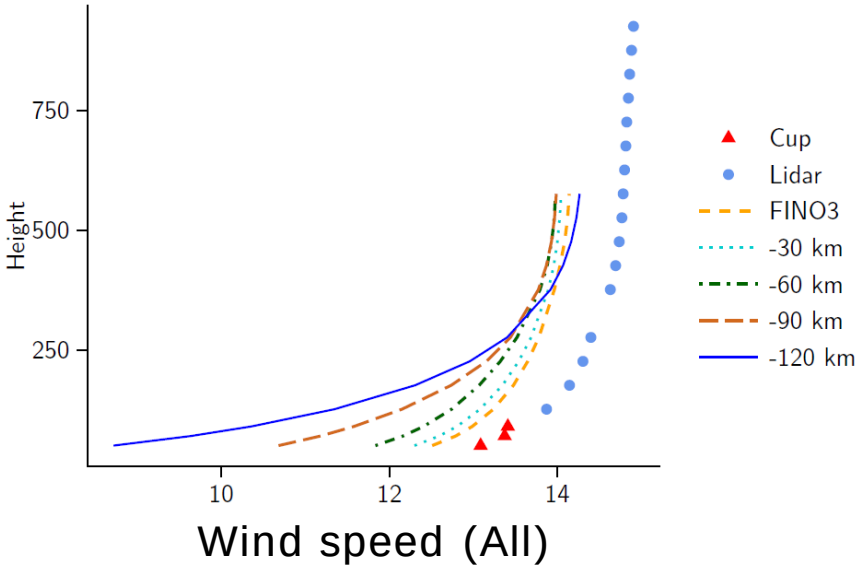


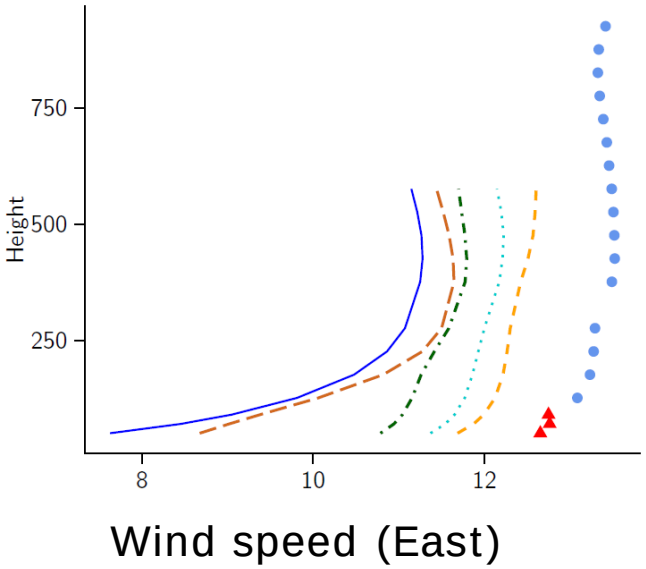


Comparing the measurements and mesoscale models

- 4 months measurements from wind lidar
- Same period as RUNE experiment
- Results from 5 grid points from the WRF model







Conclusions

- One lidar will provide necessary local measurements, scanning with azimuthal angle of +- 45 degrees seems to give good results

- If you have sufficient funds there are merits of using two lidars:
  - Higher measurement rate
  - Small portion of area sampled
  - More measurement points
  - If the flow is not horizontally homogeneous

- A high pointing accuracy is crucial in achieving reliable measurements

- Unique data set for evaluating mesoscale models

Thank you for your attention